CORRELATING POSITION OF HYOID BONE AND MANDIBLE TO THIRD CERVICAL VERTEBRA IN PATIENTS WITH CLASS I, CLASS II AND CLASS III SKELETAL MALOCCLUSION – A CEPHALOMETRIC STUDY

Dissertation Submitted to

THE TAMIL NADU DR.M.G.R. MEDICAL UNIVERSITY

Towards the partial fulfillment for the degree of

MASTER OF DENTAL SURGERY

BRANCH – V

ORTHODONTICS

SEPTEMBER 2006

Certificate

This is to certify that **Dr. VIJJAYKANTH** *Post Graduate Student (2003-2006) in the Department of Orthodontics, Tamilnadu Government Dental College & Hospital, Chennai has done this dissertation titled "***CORRELATING POSITION OF HYOID BONE AND MANDIBLE TO THIRD CERVICAL VERTEBRA IN PATIENTS WITH CLASS I, CLASS II AND CLASS III SKELETAL MALOCCLUSION – A CEPHALOMETRIC STUDY***" under our guidance and supervision in partial fulfillment of the regulations laid down by the Tamilnadu Dr.M.G.R. Medical University, Chennai for M.D.S., Branch – V Orthodontics, Degree Examination.*

Dr.L.Muthusamy, M.D.S.,
Professor and Head,
Department of Orthodontics
Tamilnadu Govt. Dental College and Hospital,
Chennai-600 003.

Dr.W.S.Manjula, M.D.S.,
Additional Professor,
Department of Orthodontics
Tamilnadu Govt. Dental College and Hospital,
Chennai-600 003.

Dr.C. Kumaravelu, M.D.S.,
Principal
Tamilnadu Govt. Dental College and Hospital,
Chennai-600 003.

C O N T E N T S

LIST OF BAR DIAGRAMS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

I thank **Dr. C. Kumaravel, M.D.S**, Principal , Tamilnadu Government Dental College and Hospital, Chennai, for granting me permission to use the facilities available in the college.

I express my gratitude to **Dr. L. Muthusamy, M.D.S.,** Professor and Head of the Department, Department of Orthodontics, Tamilnadu Government dental college and Hospital, Chennai, for the precious guidance, support and the constant encouragement throughout the entire duration of this study.

I express my sincere thanks to **Dr. W. S. Manjula, M.D.S,** Additional Professor, Department of Orthodontics, Tamilnadu Government Dental college and Hospital, Chennai, for her important suggestions, words of constructive criticism and valuable guidance in making this work possible.

I wish to extend my thanks to **Dr. C. Karunanidhi, M.D.S**, Additional Professor, Department of Orthodontics, Tamilnadu Government Dental college and Hospital, Chennai, for his support during the study.

I am bound to acknowledge the constant support and motivation extended by my Assistant Professors , **Dr. G. Vimala, M.D.S., Dr. S. Premakumar, M.D.S., and Dr. J. Nagalakshmi, M.D.S**., throughout study.

I express my gratitude to **Mr. G. Ravanan**, Reader, Statistics Department, Presidency College, for doing the statistical analysis.

Last but not the least, I wish to extend my sincere thanks to the dental students who participated in the study and my family, my batch mates and juniors who helped me in this study.

INTRODUCTION

Hyoid bone has been called the skeleton of the tongue. It is a U shaped bone that consists of an unpaired body and greater and lesser cornua / horn on each side. It is derived from the second and third pharyngeal arch cartilages.

Hyoid bone is unusual in that it articulates with no other bone, it is suspended by muscles, ligaments and connective tissue fascia of the mandible, pharynx, cranium and spine. By virtue of all these attachments hyoid bone is important in many aspects, such as balancing head on the vertebral column, prevention of regurgitation of food after swallowing, in mouth opening, maintenance of stability and patency of the pharyngeal airway.

Morphogenetic pattern of the head is established by the third month of postnatal life and once attained it does not change. In the average person at the age of three years the hyoid bone is at a level of the third and fourth cervical vertebra and gradually descends to a level of the fourth cervical vertebra by full adulthood.

By the age of two years the morphology of the first, second and the third cervical vertebrae is established. The distance between the hyoid bone and the cervical vertebrae is constant during pharyngeal growth. The antero – posterior position of the hyoid bone depends on the relative length of those muscles running to it from the base of the cranium bilaterally and from the region of mandibular symphysis (Three point suspension) and further modified by the pharyngeal and infrahyoid muscles and by gravity acting upon the larynx.

During the period of growth the hyoid descends as the cervical vertebrae increase their height, but this descent does not change the relative position of the hyoid bone to the cervical vertebrae.

The suprahyoid musculature has been implicated as one of the major factors responsible for relapse after mandibular advancement surgery. The muscles and connective tissue comprising the suprahyoid complex must adapt to increased length brought by mandibular advancement for skeletal stability to be achieved. This can be determined by the change in hyoid bone position with relation to mandible and cervical vertebra.

Hyoid bone position can be studied with the help of lateral cephalogram. Bibby has introduced “HYOID TRIANGLE” to determine the anteroposterior positin of hyoid bone with reference to third cervical vertebra and mandible. The relationship between the hyoid bone and mandible is maintained from the age of three years. Thus the anteroposterior position of hyoid bone is used to asses normal physiologic position and functions of the surrounding anatomy in this area, which is important in orthodontic and surgical relapse.

The triangle is formed by joining the cephalometric points retrognathion (the most inferior point on the mandibular symphysis), hyoidale (the most superior, anterior point on the body of the hyoid bone), C3 (the most inferior, anterior position on the third cervical vertebrae).

In this study, antero-posterior position of hyoid bone is assessed using “Hyoid Triangle” in skeletal class 1 patients and the control norms is established using 60 lateral cephalogram, consisting of equal samples of males and females of age 18 and above. Using this control and anteroposterior position of hyoid bone is compared and correlated with skeletal class II and skeletal class III patients using 20 lateral cephalogram in each group.

AIMS AND OBJECTIVES

The aim of the present study is to investigate the antero-posterior position of hyoid bone to mandible and third cervical vertebra in class I, class II, and class III skeletal malocclusion patients. The objective is to,

1. Establish a control norm for antero-posterior position of hyoid bone to third cervical vertebra in class I skeletal malocclusion patients and to determine hyoid bone position in class II and class III skeletal malocculsion.
2. Correlate the position of hyoid bone in skeletal class II and class III with that of the established control norm and to find out if there is any difference in hyoid bone position with reference to third cervical vertebra among them.
3. To find out, if there is any sexual dimorphism with hyoid bone position.
4. To establish a ratio of hyoid bone position and retrognathion to cervical vertebra and determining if it is a constant in various skeletal malocclusion groups.
5. To determine the influence of skeletal malocclusion on oropharyngeal airway.

REVIEW OF LITERATURE

Flowers W. H. (1885)[32], in describing the osteology of the Mammalia, showed a comparison between the hyoid systems of the dog and man. In the dog there is present a stylohyal, epihyal, ceratohyal, and tympanohyal; these comprise the anterior cornus. The basihyal forms the body and throhyal, the posterior cornua. In man there remain the basihyal, ceratohyal, and thyrohyal. The stylohyal of the dog becomes the styloid process in man. The tympanohyal becomes surrounded by the tympanic portion of the temporal bone and the epihyal shows no ossification in man.

Kingsley (1912)[41], in his comparative anatomy of vertebrates, wrote that the skeleton of the Mammalian tongue (hyoid apparatus) varies considerably. In its most complete development it consists of a body in the median line which bears two pairs of cornua.

Negus. V. E. (1930)[55] published his Mechanism of the Larynx. This is, by all odds, the most complete and authoritative work on the throat structure. He stated that the hyoid of many of the lower vertebrates is in closer relationship with the larynx than in higher orders. In all mammals, however the larynx, although not intimately united with the hyoid, is indirectly attached to it and certain muscles pass from one to the other. Negus postulated also that the hyoid bone and larynx are both influenced by the position of the head.

Neal H. V. and Rand H. W. (1936)[54] stated that evidence from both comparative anatomy and embryology indicates that the upper and lower jaws, the hyoid bone, the ear bones, and the laryngeal cartilages of man have evolved from the skeletal gill supports of primitive fishes. The cartilages of the second and third visceral arches ossify to form the hyoid and its cornua.

Thompson.J. R. (1941)[73] stated that the hyoid is influenced by mandibular movements. In mouth openings, since the mandible moves downward, one might expect the hyoid to do the same. Thompson found that this did not occur. The hyoid tends to remain at a constant level, moving slightly backward.

Sprague.J. M. (1943)[72] wrote that the evolution of the hyoid region is closely associated with the development and changes of the mechanisms of breathing , swallowing, phonation and with the development of the tongue.

Mainland (1945)[50] describes the hyoid as a platform which can be fixed by one set of muscles so that other muscles can work from it.

King E. W. (1952)[42] in his roentgenographic study of pharyngeal growth found that the position of the patient at the time the x-rays were made could affect the relative position of the atlas and, to a greater extent, the hyoid. He also reported in this paper that the distance between the hyoid bone and the cervical vertebrae was constant until puberty when the hyoid bone moved forward slightly. King followed the growth and position of hyoid from 6 months of age to the age of 16 years. Using the Bolton Foundation's cephalometric roentgenograms at Western Reserve University, he found that the hyoid was well above the symphysis in the infant but below it in the adult. The downward progress of the hyoid was rapid during infancy and early childhood, followed by a slow descent. Then there was an accelerated rate of descent between the tenth and twelfth years in girls and between the twelfth and sixteenth years in boys. Also, the hyoid bone moved slightly forward at puberty. King further discussed the hyoid and head position. He found that changes in the head position of the same person lead to changes in the position of the hyoid. Extending the head backward the hyoid moves back; tilting the head downwards moves the hyoid bone forwards.

Brodie A. G. (1955)[16], in describing mouth opening, brought attention to the supra hyoid muscles which suspend the hyoid, larynx, pharynx, and tongue. Since these muscles are attached at or near the symphysis of the mandible, it follows that should the hyoid bone passively follow the course of the chin, all of the above-named structures would fall back. This would shut off the air-way. This is prevented by a shortening of the suprahyoids which thus indirectly aid in mouth opening.

Durzo and Brodie (1962)[26] stated that the hyoid is relatively stable in its relationship to the cervical vertebrae. He showed that any movement of the cervical vertebrae will be exhibited by a corresponding movement of the hyoid bone. He pointed out that as man attained an upright posture the head was balanced on the vertebral column by equal muscle tensions anterior and posterior to the occipital condyles. In the accomplishment of this the hyoid bone and larynx have been pressed into service as functional parts of the postural system of the body. The behaviour of the hyoid bone in response to flexion of the cervical vertebra the hyoid is relatively stable in its relation to the cervical vertebra. Any movement of the cervical vertebrae will be exhibited by a corresponding movement of the hyoid bone. In adults the hyoid bone is positioned superoinferiorly at a level opposite the lower portion of the third and upper portion of the fourth cervical vertebrae.

Ruel W Bench (1963)[65] studied growth of cervical vertebrae as related to tongue, face and denture behaviour. He stated that the posterior nasal spine, the tongue, the mandible, and the hyoid bone were all related to the pterygoid root vertical registration line. He found a consistent relationship to the growth of the third cervical vertebra to the descent of the hyoid bone in the 12 – 19 year old sample. The relationship of the hyoid to the chin showed good correlation in the mixed and permanent dentition samples, but the regression line tended to curve in each group, suggesting that the hyoid dropped from Frankfort plane at a faster rate in each group. He found that the hyoid bone was usually located between the third and fourth cervical vertebrae at all ages. The hyoid correlated better with the chin in the mixed – dentition age group, but more consistency existed between the hyoid bone and the cervical vertebrae. The anteroposterior relationship of the hyoid bone was found slightly behind the pterygoid root vertical line, although in the young group it was forward and then returned slightly forward in the adult sample. The range is large in the study from 17 mm posterior to pterygoid vertical to 14 mm anterior to this line. The hyoid bone is suspended by musculature and seems, therefore, to be influenced not only by the mandible and base of the skull but also by the length of the neck. These vertical increases in the neck area are much greater than horizontal increases. The behaviour of the hyoid bone is more consistent with neck growth than with the chin, although both seem to be important. The high correlation of hyoid behaviour with the border of the mandible, however, tends to be important, particularly in the brachycephalic faces. The fact that hyoid lowering tends to continue after facial growth slows down seems to offer an explanation for the crowding of the dental arch. Finally the author state that in the average person at the age of 3 years the hyoid bone is at a level between 33rd and 4th cervical vertebrae and gradually descends to a level of 4th vertebra by full adulthood.

Linder Aronson (1975)[44] studied effects of adenoidectomy on the dentition and facial skeleton over a period of five years and has shown cephalometrically that the mean mandibular plane angle flattened slightly when a group of mouth breathers became nasal breathers after adenotonsillectomy

Lee W. Graber (1978)[43] studied hyoid changes following orthopedic treatment of mandibular prognathism. He studied patients treated with orthopedic chin-cup appliance for a three-year period for mandibular prognathism. This is a cephalometric study using SN plane. In this study the mandible rotated clockwise moving relatively posteriorly and inferiorly. The hyoid position also tended to move slightly posteriorly but was primarily displaced in an inferior direction. The positional alteration exceeded in amount that might be expected by growth alone. The inferior direction of change in hyoid and associated structures and the resultant lack of encroachment on the vital pharyngeal passages suggest that the stability and patency of pharyngeal airway is a primary factor in hyoid positioning.

Olwyn Diamond (1980)[58] reviewed about tonsils and adenoids as related to breathing mode, development of airway and facial forms. He stated that the evidence relating dentofacial form to breathing patterns is inconclusive.

Schendel and Epker (1980)[68] studied the results after mandibular advancement in 87 cases. They reported changes in head posture. The hyoid bone and the cervical vertebrae were brought forward in mandibular advancement cases, leading to flexion of the head. Extending the time of fixation and the use of cervical collars, as well as preoperative muscle-lengthening exercises were used to cope with the phenomenon. The surgical procedure requires a change in length and tension of the related musculature, such as, the suprahyoid, infrahyoid, the musculus longus colli and the neck extensor muscles. They also stated that suprahyoid myotomy in mandibular advancement does not influence relapse in men significantly. It does, however, induce a larger movement of the hyoid bone and the cervical vertebrae, back to the preoperative extension position of the head, than the nonmyotomy group does. Suprahyoid myotomy per se will cause a change in head posture.

Bibby and Preston (1981)[13] introduced an analysis of the hyoid bone position known as the Hyoid triangle. The triangle is formed by joining the cephalometric points. Retrognathion (the most inferior, posterior of the mandibular symphysis), Hyoidale(the most superior, anterior point on the body of the hyoid bone), and C3 (the most anteroinferior point on the third cervical vertebra). The hyoid triangle relates the hyoid bone to the vertebrae and to the mandible. Since the mandibular symphysis is at a level more comparable to the axis of rotation of the head than is the cranium, the effect of head movement will be minimised and thus the hyoid position can be determined more accurately. He applied the hyoid triangle to class I malocclusion subjects and gave standard values for dimensions of the hyoid triangle. Based on this the hyoid bone is less variable in position than previous research has suggested, which all used cranium or Frankfurt plane as references. He concluded that the anteroposterior position of the hyoid bone relative to the third cervical vertebra and AA – PNS , which is the linear distance between anterior body of the atlas and posterior nasal spine, was very constant. This finding indicates that the hyoid bone represents the anterior bony boundary of the pharynx at a lower level than posterior nasal spine. He also stated that there is no sexual dimorphism in hyoid bone position. He found that the relations of the hyoid bone position are more stable when referred to the cervical column than to the skull and the mandible. In his study about hyoid bone, he stated that the previous investigations related hyoid bone to the cranium which resulted in great variability of hyoid position on even slight movement of the head. To minimize this, he has taken third cervical vertebra and Retrognathion in mandible as landmarks which are closer to hyoid and hence the variation in determining the hyoid position will be minimal.

F. A. Sosa, T. M. Graber, T.P. Muller (1982)[31] studied post pharyngeal lymphoid tissue in Angle's class I and class II malocclusion. This study used Xeroradiographic cephalograms which provides superior visualization with edge – enhancement effect for both soft and hard tissues. They concluded that the airway space did not appear to vary with the type of malocclusion. There were only low level correlation between size of the nasopharyngeal area and certain skeletal characteristics. In this study class I males had a widening of the anteroposterior dimension of the nasopharynx in association with anterior rotation of the mandible and larger nasopharyngeal area. The same patients tend to have longer maxilla, larger SNB angle, opening of the cranial base angle and an increased distance from sella to PNS. This suggest that male class I malocclusion patients with a larger nasopharyngeal area and a deeper or wider bony nasopharynx dimension tend to have a more anteriorly positioned maxilla and mandible.

Adamidis IP, Spyropoulos MN (1983)[1] studied the effects of lymphoadenoid hypertrophy on the position of the tongue, the mandible and the hyoid bone. They found that mouth breathing affects the mandibular position, as well as hyoid bone position and orientation. They suggested that suprahyoid muscles may play a role in the establishment of growth direction of the mandible.

Hans Pancherz, Andersons Winnberg and Per-Lennart Westesson (1986)[35] investigated the masticatory muscle activity and hyoid bone behaviour during cyclic jaw movements by using a synchronized electromyographic and radioflurographic study. The EMG activity of the suprahyoid and masseter muscles and the movement of the hyoid bone to different phases of the jaw open – close-clench cycle is studied . The hyoid bone was moved downward - backward during jaw opening and the hyoid bone moved upward and forward during jaw closure. No absolute reciprocal EMG activity existed between suprahyoid and masseter muscle activity during cyclic jaw movements . A period of no EMG activity from either the suprahyoid muscle group or the masseter muscle was noted during the jaw open phase and the occlusal phase. This investigation was carried to register the EMG activity from both the jaw opening and jaw closing muscle synchronously with associated jaw and hyoid bone movements and to analyse the inter relationship between these parameter in human subjects. On the basis of mandibular position the open-close-clench cycle was divided into four phases- Opening movement, open position, closing movement and occlusal position. During the mandibular open- close-clench cycle, the hyoid bone exhibited and average an elliptical movement pattern. The suprahyoid muscles seem to play am important role in stabilization of mandible and giving smoothness to any action of the bone.

Carlson (1987)[17] studied the adaptation of the suprahyoid muscle complex to mandibular advancement surgery. Like previous studies, an anterior movement of hyoid bone immediately after mandibular advancement noted. Over time the hyoid bone tended to move back toward its preoperative position. Carlson attributed this hyoid movement to an adaptive process that occurs at the bone – tendon interface and not to the suprahyoid and infra hyoid musculature. After adaptation the hyoid tends to reside in a position close to its preoperative location.

Carlson and Ellis (1988)[18] studied maxillomandibular growth 2 years after mandibular advancement surgery with and without suprahyoid myotomy in juvenile Macaca mulatto monkey. In contradiction to Schendel and Epker's findings they reported that suprahyoid myotomy has a statistically significant effect on relapse after mandibular advancement in 10 adult rhesus monkeys.

Wenzel Ann, Stephen Williams and Martin Rikau (1989)[76] studied the relationship between changes in craniofacial morphology, changes in head posture and nasopharyngeal airway after mandibular osteotomy. The surgical procedure was mandibular bilateral vertical ramus osteotomy. The follow up is after one year. Craniofacial morphology was evaluated for 12 parameters describing sagittal and vertical jaw relationship . head posture was evaluated by the craniocervical angulation and airway as nasopharyngeal airway. After surgical procedure, changes in posture were related to changes in mandibular morphology while other correlations between posture and morphlology have been eliminated. They concluded that change in mandibular morphology and function are followed by change in head posture, but the change in posture are not induced by or related to the changes in nasopharyngeal airway resulting from mandibular osteotomy.

Greenfield, Krans and Laurence (1989)[34] studied the influence of cephalostatic ear rods on the positions of the head and neck during postural recordings.

Timms (1990)[74] hypothesized that when the tongue is carried by the mandible through surgical posterior repositioning, a reduction of the lumen of the oropharynx could occur. Consequently, the cervical hyperflexion, which was demonstrated to take place in the surgically treated patients by mandibular osteotomy, might be a compensatory response to an altered airway.

Athahasious E. Athahasiou (1991)[10] studied changes of hyoid bone position and pharyngeal depth at the level of the second and fourth cervical vertebrae and their relationships in mandibular prognathism patients who received combined orthodontic surgical treatment. Hyoid bone position and pharyngeal depth was assessed on the lateral cephalograms. They concluded, there were significant difference in the distance between hyoid bone to maxilla and mandible. The distances of the hyoid bone with the anterior cranial base, the vertebral column, and the anterior pharyngeal wall, and the measurements representing pharyngeal depth exhibited the significant changes. The hypothesis that the posterior surgical mandibular repositioning may reduce the airway at the levels of the second and fourth cervical vertebrae was not supported by the findings from this investigation. It is found that reflex alteration in the pharyngeal muscular mechanism and the biomechanical conditions of the supra and infra hyoid muscles takes place postoperatively. The authors also states that gross changes in tongue position can be assessed by analyzing changes of hyoid bone position.

J.W.PIM Valk, & JJ Zonnenberg (1992)[38] considered the effect of BSSO surgical procedure for mandibular advancement and the distance between point mention and the hyoid bone becomes longer through lengthening & there is an increase in tension of the suprahyoid muscle groups by the hyoid bone. The displacement of the dental, skeletal and neuromuscular components within the craniomandibular complex requires a large adaptive capacity and suggests that the patient develops a forward head posture (anterior—position of head).

Ioannis P.Adamidis and Meropi N.Spyropoulos (1992)[36] investigated the hyoid bone position and inclination on the cephalometric radiographs of two groups of patients exhibiting class I and class III malocclusions. The radiographs were taken in both centric occlusion and wide-opened mandibular position and 17 measurements wee performed on both tracings. Their findings showed a statistically significant difference in the position and inclination of the hyoid bone in two groups. Class III patients, especially boys, show a more anterior position of the hyoid bone and also a reverse inclination. This study also found that the relationship of the hyoid bone to the mandible and other elements of the craniofacial complex is rather constant and is influenced little by short and transient changes in posture.

Eung-Kwon Pae (1994)[29] did cephalometric and electromyographic study of upper airway structures in the upright and supine positions in OSA and normal individuals and concluded body posture has a substantial effect on upper airway structures and muscle activity in OSA and normal individuals. Horizontal variable of hyoid (H-RGn) showed significant difference in OSA group as compared with control group. The length of the pharynx was significantly shortened with OSA group, which might be the reason for inadequacy of airway in the OSA group is approximately half the size of that of the control in terms of cross-sectional area in the supine position.

Randy.J.Hayes & David Sarver(1994)[62] studied the soft tissue changes following surgical mandibular advancement in which the hyoid bone has superior movement with reference to hyoid bone for each 1 mm towards Bs, S or PNS after surgery there is a decrease in the lip-chin throat angle of 2.09°, 2.47° or 2.33° respectively. Thus as the hyoid move toward the respective stable cranial landmarks, varying degrees of improvement in lip-chin, throat angle can be expected. On mandibular advancement the hyoid bone moved toward sella, basion and posterior nasal spine. The overall movement can be described as suspension with a slight anterior component.

Ismail Ceylan & Husamettin Oktay (1995)[37] studied pharyngeal size in different skeletal patterns and concluded that a number of postural changes can occur and involve the structures of head and neck regions in response to the changes in sagittal jaw relationships. The size of the pharyngeal airway does not change appreciably. Pharyngeal structures have not been affected by sex at the age group studied (13-15 years). The subjects were divided into three groups according to ANB angle. Subjects selected breathed comfortably through nose, did not have deglutition disorder or visual or hearing disorder, did not have any wound, burn, or scar tissue in the neck. They concluded that the nasopharyngeal area was not affected by the ANB angle, but the oropharyngeal area became smaller with the increase of the ANB angle. Larger the ANB angle, less the oropharyngeal area. The sagittal measurement of the oropharynx was not affected by the ANB angle, whereas the oropharyngeal area was affected.

Anders Winnberg & Hans Pancherz (1994)[5] studied head posture and hyo-mandibular function in man using synchronized electromyographic and video fluorographic study during opening & closing chewing cycle, concluded that head posture is a significant fact9or in studies of mandibular and hyoid bone movements and masseter and suprahyoid muscle function.

Altered head posture influences the posture of the hyoid bone. Hyoid bone showed a more vertical movement pattern during backward extension of the head compared with forward flexion. A small upward forward movement of the hyoid bone is observed before the start of the opening in all head position, which is less pronounced during backward extension. A downward- forward movement of the hyoid bone was observed during the open phase just before the start of mandibular closure when the head was extended back.

N.R. Turnbull, J.M. Battagel, (2000)[56] studied the effects of orthognathic surgery on pharyngeal airway dimension and quality of sleep. Orthognathic surgery has been associated with airway narrowing and induction of sleep – related breathing disorders. The pharyngeal dimensions after orthognathic surgery were investigated and a significant difference in the retrolingual airway dimension was found in all patients after mandibular setback surgery and a significant increase in this dimension after mandibular advancement. Lateral cephalograms was used in this study and craniofacial skeletal characteristics and pharyngeal airway dimension were studied approximately six weeks after surgery. They concluded a significant reduction in retrolingual airway dimension after mandibular setback surgery in all cases. This was associated with posterior repositioning of the tongue and impingement on lingual airway space. Mandibular advancement osteotomies in the class II cases produced an increase in both the retrolingual and post-palatal airway dimensions and a postural change of the soft palate. In class III setback surgery cases a decrease in retropalatal airway width is seen even when combined with maxillary advancement procedure. In the short term orthognathic surgery causes pharyngeal dimensional changes, but in majority of young and healthy subjects, this has little effect on sleep quality.

Armando Gale and Laine-Alava (2001)[9] studied hyoid bone position after surgical mandibular advancement. The results indicated that with surgical mandibular advancement the hyoid bone follows mainly the advancement of the mandible. It moves closer to the body of mandible, which might be due to the tensile forces of the attached musculature. They found however that there is a variation in the changes of the hyoid bone and head position, and their final position is difficult to predict.

Shigetoshi Hiyama & Takashi (2001)[69] showed that night time wear of cervical head gear produced significantly forward movement of hyoid bone & third cervical vertebra – the relationship among the mandibular symphysis, the hyoid bone and the third cervical vertebra did not change. C3-H- closely related to the sagittal dimension of the upper airway which is significantly decreased by wearing Cervical Head gear during sleep, although there is only counterclockwise rotation of mandible and no significant anteroposterior displacement of the mandible.

Dong Hwa Chung, John P. Hatch, Calogero Dolce, Joseph E. Van Sickels, Robert A Bays, and John D. Rugh (2001)[25] studied the positional change of hyoid bone after bilateral sagittal split osteotomy with rigid wire fixation. In this study radiographs were taken before surgery, immediately after surgery, eight weeks, six months , one year, and two years after surgery. The wire group had greater sagittal relapse of the hyoid bone. Both groups showed upward movement of the hyoid bone after surgery. There was no relationship between the vertical change in the position of hyoid bone and the vertical position of mandible. The rigid group showed no significant change in distance form the hyoid to the genial tubercles, but the wire group showed recovery of muscle length after six months. In this study, the average vertical change in the hyoid bone due to surgery from presurgical to 8 weeks period was only 1.5 mm in the wire group and 1.9 mm in the rigid group with a large standard deviation. In this study the hyoid bone moved forward with surgery in both groups. The hyoid showed more relapse in the wire group than in the rigid group. In the wire group, the hyoid moved to its preoperative position during the retention period. The change in the position of the hyoid bone after surgery was found by projecting the final hyoid position on the sella reference plane. In both groups superior movement of hyoid bone from 8 weeks post-operatively compensated for the lengthening of the superior hyoid muscle group. There was no relationship between vertical change in hyoid bone and the vertical component of the mandible position.

Pushkar Mehra and Michael Downie (2001)[61] found from their retrospective study that counterclockwise rotation of the maxillomandibular complex significantly affects the pharyngeal airway space and velopharyngeal anatomy in patients with high occlusal plane facial morphology. Their study also states that when counterclockwise rotation of the maxillo mandibular complex is performed, the genial tubercles move forward a greater amount than the teeth, thereby maximizing the forward movement of the hyoid bone, the base of the tongue, and other associated soft tissues.

Winnberg and Pancherz (1986)[35] investigated the relationship between head posture and hyomandibular function in man. They used synchronized electromyographic and videofluorographic methods during open-close-clench cycle. They concluded that head posture is a significant factor in studies of hyoid bone movements.

Wenzel and Williams (1989)[76] studied relationships of changes in craniofacial morphology, head posture and nasopharyngeal airway size following mandibular osteotomy. It was found that after surgery a decrease in the anteroposterior dimension of nasopharynx was demonstrated in 83 percent of the patients and on the average a cervical hyperflexion occurred.

Bidyut K.Medda and Mark Kern (2003)[14] found from their study that significant species difference in the anatomic position of the larynx in relationship to the body and gravity exists. For example, the larynx in cats is oriented perpendicular to gravity, whereas in adult humans the larynx / pharynx is oriented parallel with gravity. So animal studies can yield no useful information about hyoid positions of humans.

Elham Saleh Abu Allhaija, Susan Nadeem Al-Khateeb (2005)[27] investigated the Uvulo-Glosso-Pharyngeal dimensions in subjects with different anteroposterior jaw relationship. The subjects were divided into skeletal class I (ANB 1-5^0), skeletal class II (ANB >5 ^{0}), and class III (ANB < 1^0). The groups were divided into subgroups according to sex. They concluded that there were sex differences between class I and class III subjects . tongue height was reduced in class II female subjects , soft palate was thicker in class III females and the vertical airway length was reduced in class II male subjects. In class II subjects the hyoid bone was closer to the mandible vertically and to C3 horizontally compared with class I and class III male subjects. Anteroposterior skeletal pattern showed a weak correlation between the vertical position of the hyoid and mandibular plane. Vertical position of hyoid bone in relation to mandibular plane differed significantly between the three groups. In class II subjects, hyoid bone was located in an upward and backward position , where as it was located in downward and forward position in class III subjects.

MATERIALS AND METHODS

SUBJECT SELECTION CRITERIA:

Dental students of Tamilnadu Government Dental college & Hospital with the age group from 18-30 years and, patients undergoing orthodontic treatment in the Department of Orthodontics in Tamilnadu Government Dental College & Hospital were selected as sample of the present study. The mean age of the subjects was 19.6 years. The total size of the sample in this study is 100.

All the subjects had no positive medical history. For establishing control norm in skeletal Class I group, 60 samples are taken consisting of 30 males and 30 females. To check the sexual dimorphism, equal number of males and female subjects were selected for the study.

Using hyoid triangle a standard set of values are established for all the variables and a mean value with standard deviation is given for skeletal class I control group. After establishing a control norm, 20 subjects of skeletal Class II malocclusion and 20 subjects of skeletal Class III malocclusion are compared with that of the skeletal Class I group for positional variation of the hyoid bone.

The mean age group of Class I was 20.37 with a standard deviation of 2.68. In Class II group, the mean age was 18.95 with a standard deviation of 1.57 and in Class III the mean was 18 with SD of 3.95.

The overall mean age of male was 19.65 with SD of 3.6, female 19.57 with SD of 2.50 in this study comprising of total number of 100 samples. In Class I the mean age of male was

20.93 with SD of 3.32., female mean 19.80 with SD of 1.7. In Class II male 19.67 with SD of 1.75. female mean 18.64 with SD of 1.45. In Class III male 17.07 with SD 3.43, female 20.80 with SD of 4.44.

ASSESING HYOID BONE POSITION

The position of hyoid is assessed using Hyoid triangle as given by *BIBBY and PRESTON.*

THE HYOID TRIANGLE

Hyoid triangle is formed by joining the cephalometric points Retrognathion(the most inferior and posterior point on the mandibular symphisis), hyoidale (the most superior, anterior point on the body of the hyoid bone), and C_3 (the most antero -inferior point on the third cervical vertebra).

HYOID RATIO

For determining the antero -posterior position of hyoid in various skeletal malocclusion, a ratio is established consisting of linear measurements of C_3 to Retrognation and C_3 to hyoidale. Since hyoid bone position and Retrognathion are variable points, direct linear measurement comparisons will not give accurate results. So a ratio is established for comparison.

$$\text{Hyoid ratio} = \frac{\text{linear measurement of } C_3 \text{ to RgN}}{\text{linear measurement of } C_3 \text{ to hyoid}}$$

CEPHALOMETRY

Lateral cephalograms were used to assess the hyoid bone position. Radiographs were taken for all the subjects from PAN-ORO DENTAL X-rays, Chennai. Cephalograms were hand traced and landmarks identified.

DEFINITIONS OF CEPHALOMETRIC POINTS AND PLANES USED IN HYOID TRIANGLE.

C_3 – The point at the most inferior anterior position on the third cervical vertebrae

RGn (retrognathion) – the most inferior posterior point on the mandibular symphysis.

H (hyoidale) – the most superior, anterior point on the body of the hyoid bone.

Hyoid plane – The plane from H along the long axis of the greater horns of the hyoid bone.

AA – The most anterior point on the body of the atlas vertebrae seen on the lateral cephalometric radiograph.

PNS (posterior nasal spine) – The tip of the posterior nasal spine seen on the lateral cephalometric radiograph.

Linear measurement:

1. C_3 – RgN – antero -posterior dimension between third cervical vertebra and mandible.
2. C_3 – H - antero -posterior dimension between C_3 and Hyoid.
3. H-RgN - Antero-posterior dimension between hyoid and mandible.

4. H-H[1] - vertical dimension or position of hyoid bone with reference to C_3 and RgN plane.
5. AA-PNS - linear measurement between anterior body of atlas to posterior nasal spine.

ANGULAR MEASUREMENTS:

HPA – hyoid plane angle - Hyoid plane angle - The most superior posterior angle made by the intersection of the hyoid plane with C3-RGn.

CEPHALOMETRIC CRITERION:

For establishing the skeletal pattern values from DOWNS , STEINER'S AND WITS were used.

DOWN'S:

FA- facial angle

AC-angle of convexity.

ABPA- AB plane angle

WITS : AO & BO

STEINERS :

SNA – angle formed between sella – nasion and point A.

SNB – angle formed between sella – nasion and point B

ANB – angle formed between point A , nasion and point

NHP - Natural Head Position was determined by the self balance position, that is, the subjects were asked to stand at ease and in an unstrained manner and to adjust their heads . The subjects were asked not to swallow, not to move their heads and tongues, and to keep their teeth in contact lightly while the radiographs were being taken. The radiographs were taken by usual standardized methods.

To determine the errors associated with radiographic measurements, 25 radiographs were selected at random from the control group. The tracings and the measurements of these films were repeated two weeks after the first measurement. A paired 't' test was applied to the first and second measurements and no error associated with radiographic tracings and measurements was found.

STATISTICAL METHODOLOGY:

The mean and standard deviation for each variable is established for different Classes. Students 't' test was used to determine values for independent male and female samples. Pearson's correlation coefficient were determined to appraise the strength of relationship between the variables in each group. The hyoid ratio for different groups or Classes is compared or correlated using Multiple Range Tests-- Tukev-HSD tests with significance level .050. SPSS package (SPSS inc) software was used for statistical analysis.

TABLE – I

CEPHALOMETRIC MEAN AND STANDARD DEVIATION FOR EACH GROUP

P value ≤ 0.01 = ** Highly significant

P value < 0.05 = * Significant

P value > 0.05 = Not significant

TABLE – II

CEPHALOMETRIC MEAN AND STANDARD DEVIATION FOR MALES & FEMALES FOR EACH GROUP

P value ≤ 0.01 = ** Highly significant

P value < 0.05 = * Significant

P value > 0.05 = Not significant

TABLE – III

T- TEST FOR INDEPENDENT SAMPLES OF SEX: CLASS I GROUP

P value ≤ 0.01 = ** Highly significant

P value < 0.05 = * Significant

P value > 0.05 = Not significant

TABLE - IV

T- TESTS FOR INDEPENDENT SAMPLES OF SEX - CLASS II GROUP

Class II group	Sex				t value	P - value
	Male		Female			
	Mean	SD	Mean	SD		
C3 – RGn	68.00	6.42	68.29	5.81	0.10	0.923
C3 – H	38.00	3.03	34.14	2.66	2.86	0.010
H – RGn	30.67	5.79	35.43	4.48	2.00	0.061
$H – H^1$	4.83	1.60	4.93	3.73	0.06	0.0953
HPA	32.83	8.82	30.00	11.83	0.52	0.607
AA - PNS	32.00	3.29	34.93	3.20	1.86	0.079

P value ≤ 0.01 = ** Highly significant

P value < 0.05 = * Significant

P value > 0.05 = Not significant

TABLE V

T TEST FOR INDEPENDENT SAMPLES OF SEX – CLASS III GROUP

P value ≤ 0.01 = ** Highly significant

P value < 0.05 = * Significant

P value > 0.05 = Not significant

TABLE VI

PEARSON'S CORRELATION COEFFICIENT

CORRELATION COEFFICIENT FOR CLASS I

	C3 - RGn	C3 - H	H - RGn	HH	HPA	AA - PNS
C3 – RGn	1.0000					
C3 – H	0.7673**	1.0000				
H – RGn	0.7671**	0.2812*	1.0000			
H – H^{1}	0.1872	0.4272**	0.2465	1.0000		
HPA	0.2169	0.0666	0.3039*	0.1176	1.0000	
AA – PNS	0.2733*	0.2093	0.2376	0.1763	-.0058	1.0000

TABLE VII

CORRELATION COEFFICIENT FOR CLASS II

	C3 - RGn	C3 - H	H - RGn	HH	HPA	AA – PNS
C3 – RGn	1.0000					
C3 – H	0.3834	1.0000				
H – RGn	0.8238**	-.1605	1.0000			
H – H[1]	0.1912	0.1909	-.1161	1.0000		
HPA	0.0826	0.2536	-.1587	0.4061	1.0000	
AA – PNS	0.2879	-.0298	-.2253	0.2843	-.1285	1.0000

TABLE VIII

CORRELATION COEFFICIENT FOR CLASS III

	C3 - RGn	C3 - H	H - RGn	HH	HPA	AA - PNS
C3 – RGn	1.0000					
C3 – H	0.4867*	1.0000				
H – RGn	0.7984**	-.1128	1.0000			
H – H^1	-.0574	-.2973	0.2454	1.0000		
HPA	0.0312	-.4070	0.3647	0.5461*	1.0000	
AA – PNS	0.5516*	0.3535	0.3287	-.2105	-.4109	1.0000

TABLE – IX

HYOID RATIO

MULTIPLE RANGE TESTS : TUKEY – HSD

Class	H Ratio		P value
	Mean	SD	
Class I	2.07^{b}	0.18	
Class II	1.94^{a}	0.19	0.031^{*}
Class III	2.06^{ab}	0.20	

Note: * denotes significance at 5% level.
Different alphabet between class denotes significance at 5% level.

INFERENCE

SKELETAL CLASS I GROUP:

In the present study there is statistical significant difference between male and female subjects studied with analysis of variance for C3 – RGn, C3 – H, and H – H^1 variables. There is statistically insignificant difference for H – RGn, HPA and AA – PNS between male and female subjects.

The mean value for C3 – RGn in male subjets is 79.27 ± 5.87 and in female is 71.13 ± 5.76.

The mean value for C3 –H in male subjects is 40.33 ± 3.33. The mean value for C3-H in female subjects is 33.00 ± 3.33.

The mean value for H – H^1 for male subjects is 5.87 ± 5.71. and for female is 3.50 ± 2.40.The mean value for H –RGn is 39.78 ± 4.94.The mean value for HPA is 31.28 ± 11.24The mean value for AA – PNS is 34.12 ± 3.36

SKELETAL CLASS II GROUP:

There is statistically significant difference only for C3 - H variable in skeletal class II group,. The mean for C3 – H for male subjects is 38.00 ± 3.03 and in female, the mean value for C3 – H is 34.14 ± 2.66.

For all the other five variables studied there is no statistically significant difference between male and female subjects.

The mean value for C3 – RGn is 18.95 ± 1.57 The mean value for H – RGn is 35.30 ± 3.25The mean value for H – H^1 is 4.90 ± 3.19. The mean value for HPA is 30.85 ± 10.86

The mean value for AA – PNS is 34.05 ± 3.43

SKELETAL CLASS III GROUP:

Statistically, there is no significant difference between male and female for all the variable studied. The mean value for C3 – RGn is 81.75 ± 7.04. The mean value for C3 – H is 39.90 ± 3.88. The mean value for H – RGn is 43.05 ± 6.13. The mean value for H – H^1 is 6.10 ± 3.32. The mean value for HPA is 24.90 ± 10.91. The mean value for AA – PNS is 34.10 ± 4.15

PEARSON'S CORRELATION COEFFICIENT

CORRELATION COEFFICIENT OF VARIABLES WITHIN EACH GROUP:

Pearson's correlation coefficient (r) is the index of extent to which two variables are associated

SKELETAL CLASS I GROUP:

In skeletal class I group high degree of correlation is present the correlation between C3 – H and C3 – RGn is 76%. Between H - RGn and C3 - RGn is 76%.

H – H^1 and c3-h is 42%. HPA and H - RGn is 30%. AA - PNS and C3 - RGn is 27%.

SKELETAL CLASS II GROUP:

In this group, statistically significant correlation is seen only between H - RGN and C3-RGn - 82%

SKELETAL CALSS III GROUP:

In skeletal class III group there is statistically significant correlation is seen between the following variables:

correlation between C3 – H and C3-RGn IS 48%

correlation between H – RGN and C3 – RGn is 79% .

correlation between HPA- HH IS 54%.

correlation between AA-PNS and C3 – RGN IS 55% .

HYOID RATIO

Hyoid ratio is studied between three groups by using Multiple Range Tukev – HSD test.

Hyoid ratio is very similar in all the groups studied. There is statistically significant difference between skeletal class I and skeletal class II group. Hyoid ratio for skeletal class I group is 2.0 ± 0.18. Hyoid ratio for skeletal class II group is1.9 ± 0.19. Hyoid ratio for skeletal class III group is 2.0 ± 0.20.

DISCUSSION

Traditionally hyoid bone is one of the most overlooked component of the craniofacial skeleton, however importance of hyoid bone in maintaining airway, deglutition and head posture have been adequately documented. The recent emphasis in obstructive sleep apnea and its management has renewed interest in the study of hyoid bone.

The hyoid bone is a unique component of the axial skeleton, because it does not articulate with any other bone rather it is suspended from the styloid process of temporal bone by ligaments and muscles. Located in the anterior neck, between the mandible and larynx the hyoid bone supports the tongue and provides attachment for tongue muscles and for muscles of neck and pharynx. The hyoid consists of a horizontal body and paired projections called the lesser horns and greater horns. The hyoid forms a delicate balance between suprahyoid and infrahyoid group of muscles. By these attachments the hyoid bone is connected to and influenced by the tongue, the mandible, the base of the skull , sternum , the scapula , the thyroid cartilage and the pharynx.

Hyoid bone ossifies first in the body and then ossification proceeds to greater horns. By age 14, the hyoid is completely ossified [60]. Hyoid acts as a platform for the other muscles to function properly. By fixing one set of muscles this hyoid platform can be stabilized so that other muscles can act from it[50]. A chain of muscles encircles the head from back to front and the functioning of these muscles is important for posture of the head on the spinal column. The hyoid bone serves as the link with its supra hyoid and infra hyoid musculature. When these muscles are flexed, the head is tilted down. When they are relaxed, the head can be tilted back. When these muscles are in isometric contraction they help hold the head erect[16]. Sicher states that the hyoid can be designated as the skeleton of the tongue[70]

The hyoid is very essential in early life in keeping the pharynx air passage open [15]. Hyoid bone is well above the symphysis in the infant and moves well below it in the adult. During infancy and early childhood, the downward progression of the hyoid is rapid followed by slow descent later. Between 10-12 years in girls and between 12-16 years in boys there is an accelerated rate of descent. Hyoid bone moves slightly forward at puberty[42].

Hyoid bone moves forward and slightly upward during protrusion from centric position and it moves downward and backward in maximum opening of the mandible [71].

Hyoid bone position is determined by the musculature attached to it and not by the occlusion. The position of hyoid in Angle's Class I, Class II and Class III malocclusion is the same and does not vary[33]. As the hyoid descends during growth of the cervical, cranial and mandibular development, its position relation to these areas remains the same[26]. During swallowing hyoid bone moves upward and forward and then downward and back. The bone moves in a small oblong circle[46].

The vertical descent of hyoid is accelerated during puberty and thus the tongue with its attached musculature to hyoid also moves downward and occupies a lower position in the floor of the mouth. So, only after puberty, functional maturity of tongue is completely established. This may be important in patients with tongue thrusting habit, which is seen in majority of children with mixed dentition, where the hyoid bone occupies a relatively more superior position and hence the tongue also occupies a more superior position in the floor of the mouth.

Hyoid bone position is important in determining successful orthopedic chin cup treatment in skeletal class III nalocclusions[43], for prediction of surgical relapse following advancement BSSO for skeletal class II retrognathic patients[66], in predicting soft tissue morphology changes following orthognathic surgery[62], for maintenance of oropharyngeal airway[29].

This study is undertaken to exactly determine the position of hyoid in various skeletal malocclusion groups and to compare and correlate the position of hyoid in these groups. The hyoid triangle given by **Bibby and Preston**[13] was taken into consideration for the study and the hyoid ratio was established from the hyoid triangle.

The present study had established a mean value for hyoid bone position in skeletal class I group using hyoid triangle. In the present study sexual dimorphism is present and it is contradictory to the study by **Bibby** and **Preston**[13] in which they stated there is no sexual dimorphism.

But this study correlates with the study by **Elham saleh Abu Allhaija, Susan Nadeem Al- Khateeb**[27]**,** in which they obtained sexual dimorphism for hyoid bone position between different skeletal malocclusion groups. So, in this study separate mean values are given for males and females.

In the present study significant difference is seen in the hyoid bone position with reference to third cervical vertebra in skeletal class I and class II group. Hyoid ratio is similar in different skeletal pattern which implies that in skeletal class II group, hyoid is positioned posteriorly and in skeletal class III group the hyoid is positioned anteriorly.

But there is only statistical significant difference between class I and class II group.

In this study, the C3 – RGn, gives the distance between third cervical vertebra and Retrognathion of mandible. Its mean value is higher in male subjects than in female subjects. This implies that the male subjects in skeletal class I group the mandible is positioned more anteriorly when compared to female subjects. This gender difference can be explained by the difference of mandibular length between males and females given by **Charles J.Burstone and Legan.**[20,9]**.**

In class II patients, there is no difference between male and female subjects.

In class III group, though there is not much difference seen between male and female subjects, wide range of values is noted for male subjects.

The variable C3 – H which describes the anteroposterior position of hyoid from third cervical vertebra is constant in all the groups for both the male and female subjects. The mean value for this variable is higher in male subjects than in female subjects in all the groups studied. This implies that the hyoid is relatively placed closer to third cervical vertebra in females than in males and hence the oropharyngeal dimension is smaller in females than in males[27]. In all the groups studied the mean value for this variable is very constant with minimum standard deviation, indicating that the hyoid bone position is very constant in a particular skeletal group for male and female subjects. This correlates with the finding of **Bibby and Preston**[13]**,.Durzo and Brodie**[26] and **Shigetoshi, Hiyama** and **Takashi**[69]**.**

The variable H – RGn denotes the distance between the hyoid bone and the mandible. In class I subjects, its value is higher in male subjects than in female subjects which implies that the size of the mandible is relatively larger in males than in females.

In class II, the H – RGn value is lesser in males than in female subjects. This implies that the hyoid is more closely placed to mandible and it correlates with the finding that the hyoid is positioned more anteriorly with reference to third cervical vertebra in males than in females. The hyoid is placed closer to third cervical vertebra in females than males.

In class III group, the H – RGn value is more in female than in male subjects, which denotes that the hyoid is more closely placed to mandible in males. The standard deviation is more in male and female subjects denoting the varying position of hyoid bone in this group.

H – H' denotes the vertical position of hyoid with reference to C3 and RGn plane.

Regarding the vertical position of the hyoid bone **Durzo and Brodie**[26] states that hyoid bone maintains the position at level between the bottom of third and top fourth cervical vertebrae. **Ruel W. Bench**[65] states that in an average person the hyoid bone is at the level of fourth cervical vertebrae in adults. Contradictory to this, the vertical position of the hyoid varied widely from C2 – C4 in this study. This has resulted in high degree of variability and standard deviation. Hence a standard set of values cannot be obtained for vertical position of hyoid for a particular skeletal group.

Hyoid plane used in this study was first given by **Michael Stepovitch**[51]**.**

HPA (Hyoid Plane Angle) is the angle formed by intersection of hyoid plane and C3-RGn. There is very high variability in the values obtained in this study denoting that the hyoid bone angulation in class I, II and III groups studied vary widely. There is also a gender difference in all the groups. The value is higher for males. In this study there is high difference between class I and class III group. This correlates with the findings of **Ionnis P Adamidis and Meropi Spyropoulos**[36] whose study showed significant difference in the position and inclination of the hyoid bone between skeletal class I and class III malocclusion groups and especially boys of skeletal class III groups showed more variation.

AA – PNS – distance between anterior body of atlas and posterior nasal spine, which denotes the bony anteroposterior dimension of the pharynx at the level of first cervical vertebra. It is constant in each group studied and there is no gender difference. The value is similar in all the three groups and hence the anteroposterior airway dimension for all the groups is similar at this level of pharynx .This finding indicates that the hyoid bone represents the anterior bony boundary of the pharynx at a lower level than posterior nasal spine This correlates with the study **of Bibby** and **Preston**[13] and **Shigetoshi Hiyama and Takashi** [69]**,** in whose studies, the linear distance between anterior body of atlas and posterior nasal spine (AA-PNS) was constant.

There is high degree of correlation between C3 – H and C3 – RGn in skeletal class I and III group, which implies that the hyoid bone is positioned closely to mandible with reference to its length. In class II patients there is less correlation between C3 – RGn and C3 – H meaning that the hyoid position is variable with reference to mandibular length. This correlates with the skeletal class II subjects where the C3 – RGn value is similar between male and female subjects but the hyoid is positioned more posteriorly in females than males. Hence there is less correlation between these values.

Between H – RGn and C3 – RGn there is high degree of correlation in all the groups meaning that the hyoid is placed more closer to the mandible with reference to its length. This implies that the hyoid has followed the mandible in the anterior direction during growth .

C3 – H and H – RGn. This variable did not correlate because both the hyoid and mandible is very variable in anteroposterior position.

No correlation is present between C3 – RGn and H – RGn which signifies that the vertical position of hyoid is very variable and did not depend on the anteroposterior position of the mandible.

No significant correlation is seen between the hyoid plane angle and other variables.

HYOID RATIO values are very similar in skeletal class I, II and III group with very minimal standard deviation. This implies that the hyoid bone position depends on the mandibular length. In skeletal class III group it is positioned more anteriorly and in skeletal class II group it is positioned more posteriorly [59,1,11,12]. The hyoid ratio obtained is 2.0, 1.9 and 2.0 for skeletal class I, II and III respectively.

This correlates with the study done by **BATTAGEL**[11,12] in which he reported a more posterior position of the hyoid bone in class II skeletal malocclusion subjects. This also corrletes with the study done by **ADAMIDIS AND SPYROPOULOUS** [1] in which they reported more anterior position of hyoid in skeletal class III malocclusion subjects.

Significant difference in anteroposterior position of hyoid in skeletal class I and class II subjects implies that hyoid is positioned more posteriorly in skeletal class II group when compared to class I group. Because of retroposition of hyoid bone, the oropharyngeal airway must adapt to maintain proper airway. If this does not happen there will be airway inadequacy. Airway obstruction is a major complication in severe retrognathic mandible like Pierre Robin syndrome, Treacher collin syndrome [22,24]. This study shows that even moderate retrognathic mandible has got clinical implication when it comes to adaptation of oropharyngeal airway dimension. This positively correlates with the observations of **Pushkar Mehra and Michael Downie**[61] that most of the observed patients with OSA symptoms have mandibular retrognathism. Since hyoid is positioned more posteriorly in skeletal class II group, they are more prone to develop airway restriction problems.

SUMMARY AND CONCLUSION

The present study was carried out to establish a control norm in skeletal class I patients for hyoid bone position and to compare and correlate hyoid bone position with reference to third cervical vertebra and retrognathion of mandible in skeletal class I , class II and class III groups. Lateral cephalometric radiographs of 100 subjects were divided into three groups, i.e., group 1, skeletal class I malocclusion; group 2, skeletal class II malocclusion and group 3, skeletal class III malocclusion respectively.

Hyoid bone position is determined by using Hyoid triangle given by **Bibby and Preston.** Hyoid bone position is also compared and correlated in skeletal class I, class II and class III malocclusions by using Hyoid ratio which is obtained from hyoid triangle.

Lateral cephalograms were hand traced and linear and angular dimensions calculated. The mean and standard deviation is obtained for all the variables studied . The hyoid ratio obtained is compared with all the three groups studied.

The hyoid ratio obtained is very similar in all the three skeletal malocclusion group studied with very minimal standard deviation denoting the anteroposterior change of hyoid bone position with relation to change in mandibular position.

The finding of this study has got significance with reference to oropharyngeal airway patency in skeletal class II malocclusions.

The following conclusions were drawn from this study,

1. Standard values are given for the dimensions of the hyoid triangle.
2. Hyoid bone is positioned more anteriorly in class III skeletal malocclusion subjects, and it is placed more posteriorly in class II skeletal malocclusion subjects when compared to

skeletal class I group with reference to third cervical vertebra and Retrognathion of mandible.

3. Hyoid ratio is obtained for skeletal class I, II and III skeletal malocclusion groups.

   The hyoid ratio for skeletal class I group is 2.0 ± 0.18.

   The hyoid ratio for skeletal class II group is 1.9 ± 0.19

   The hyoid ratio for skeletal class III group is 2.0 ± 0.20.

   Hyoid ratio derived is very similar with minimal standard deviation in all the three groups studied.

The present study has helped us to correlate the hyoid bone position in skeletal class I, class II and class III malocclusion and to determined the sexual dimorphism of hyoid bone. Hyoid bone position is important in determining successful orthopedic chin cup treatment in skeletal class III malocclusions, for prediction of surgical relapse following advancement BSSO for skeletal class II retrognathic patients, in predicting soft tissue morphology changes following orthognathic surgery and for maintenance of oropharyngeal airway.

The study also determines the influence of skeletal malocclusion on oropharyngeal airway.

BIBLIOGRAPHY

1. Adamitis PI, Spyropoulos NM.1983. The effects of lymphadenoid hypertrophy on the position of the tongue, the mandible and the hyoid bone. European Journal of Orthodontics 5 : 287-294.

2. Alan A. Lowe, John D. Santamaria, John A. Fleetham and Colin Price. 1986. Facial morphology and obstructive sleep apnea. American Journal of Orthodontics and Dentofacial Orthopedics : 484-491.

3. Alexander J. Wildman. 1961. Analysis of tongue, soft palate and pharyngeal wall movement. American Journal of Orthodontics and Dentofacial Orthopedics 47: 439-461

4. Amandeep Johal, Joanna M. Battagel. 1999. An Investigation into the changes in airway dimension and the Efficacy of Mandibular advancement appliances in subjects with obstructive sleep apnoea. British Journal of Orthodontics 26: 24-29

5. Anders Winnberg, Hans Pancherz and Per-Lennart Westesson.. 1994. Head Posture and hyo-mandibular function in man. A synchronized electromyographic and videofluorographic study of the open-close-clench cycle. American Journal of Orthodontics and Dentofacial Orthopedics 94: 393-404.

6. Anette M.C. Fransson, Ake Tegelberg, Bjorn A. H. Svenson, Bertil Lennartsson and Goran Isacsson. 2002. Influence of mandibular protruding device on airway passages and dentoacial characteristics in obstructive sleep apnea and snoring. American Journal of Orthodontics and Dentofacial Orthopedics 122: 371-379.

7. Archilleos S. Krogstad. , Lyberg T . 2000 ; Surgical mandibular set back and changes in uvuloglossopharyngeal morphology and head posture ; a short –long –term cephalometric study in males 22 : 367-381

8. Archilleos S. Krogstad. 2000. Surgical mandibular advancement and changes in uvuloglossopharyngeal morphology and head posture ; a short –long –term cephalometric study in males European Journal of Orthodontics 22: 383-394.

9. Armando Gale, Pauli V.J. Kilpelainen, Maija T. Laine-Alava. 2001. Hyoid bone position after surgical mandibular advancement. European Journal of Orthodontics : 696-701

10. Athanasios E. Athanasiou, Nick Toutountzakis, Dimitrios Mavreas, Martin Ritzau and Ann Wenzel. 1991. Alterations of hyoid bone position and pharyngeal depth and their relationship after surgical correction of mandibular prognathism. American Journal of Orthodontics and Dentofacial Orthopedics 100: 259-265.

11. Battagel JM, Johal A, L'Estrange PR, Croft CB, Kotecha B. 1999. Changes in airway and hyoid position in response to mandibular protrusion in subjects with obstructive sleep apnea. European Journal Of Orthodontics 21: 363-375.

12. Battagel JM, L'Estrange PR. 1996. The cephalometric morphology of patients with obstructive sleep apnea. European Journal Of Orthodontics 18: 557-569

13. Bibby R E , Preston C B . 1981. The Hyoid triangle. American Journal of orthodontics and Dentofacial orthopedics 80: 92-97.

14. Bidyut K Medda, Mark Kern, Junlong Ren, Pengyan Xie, Seckin O. Ulualp, Ivan M. Lang and Rexa Shaker. 2003. Relative contribution of various airway protective mechanisms to prevention of aspiration during swallowing. American Journal of Physiology 284: G933-G939.

15. Bosma J. F. 1949. Maturation of function of the oral and the pharyngeal region. American Journal of Orthodontics and Dentofacial Orthopedics 94-104.

16. Brodie A. G. 1950. Anatomy and Physiology of the head and neck musculature. American Journal of Orthodontics 36: 837-844.

17. Carlson Davidson , Edward Ellis .1987. Adaptation of the suprahyoid muscle complex to mandibular advancement surgery American Journal of Orthodontics and Dentofacial Orthopedics ;92:134-43

18. Carlson and Ellis .1988. Maxillomandibular growth 2 years after mandibular advancement surgery ;94:491-502

19. Carmine A Durzo, Allan G. Brodie. 1962. Growth Behaviour of the Hyoid Bone. The Angle Orthodontist 3: 193-204.

20. Charles J Burston, Randal B. James, H. Legan. 1978. Cephalometrics for orthognathic surgery 36: 269-275.

21. David C. Quast, Robert H. Biggerstaff, and John V. Haley. 1983. The short-term and long-term soft tissue profile changes accompanying mandibular advancement surgery. American Journal of Orthodontics and Dentofacial Orthopedics: 29-36.

22. David L. Mandell, Robert F. Yellon and James P . Bradley. 2004. Mandibular distraction of micrognathia and severe upper airway obstruction. Archives otolaryngology Head Neck surgery 130: 344-348.

23. David S. Carlson, Edward Ellis, and Paul C. Dechow. 1987. Adaptation of the suprahyoid muscle complex to mandibular advancement surgery. American Journal of Orthodontics and Dentofacial Orthopedics 92: 134-143.

24. Davinder J. Singh and Scott. P. Bartlett. 2005. Congenital mandibular hypoplasia; Analysis and Classification. Journal of Craniofacial Surgery 16: number 2.

25. Dong Hwa Chung, John P. Hatch, Calogero Dolce, Joseph E. Van Sickels, Robert A. Bays, and John D. Rugh. 2001. Positional change of the hyoid bone after bilateral sagittal split osteotomy with rigid and wire fixation. American Journal of Orthodontics and Dentofacial Orthopedics 119: 382-389

26. Durzo and Brodie. 1962. Growth behaviour of the hyoid bone. American Journal of Orthodontics 32: 193 – 202.

27. Elham saleh Abu Allhaija, Susan Nadeem Al- Khateeb .2005. Uvulo –glosso-pharyngeal dimensions in different anteroposterior skeletal patterns. The angle Orthodontist. 75: 1012 -1018.

28. Eung-Kwon Pae, Alan A. Lowe, John A. Fleetham. 1997. A role of pharyngeal length in obstructive sleep apnea patients. American Journal of Orthodontics and Dentofacial Orthopedics 111: 12-17.

29. Eung-Kwon Pae, Alan A. Lowe, Kelichi Sasaki, Colin Price, Masafumi Tsuchiya and

John A. Fleetham. 1994. A cephalometric and electromyographic study of upper airway structures in the upright and supine positions. American Journal of Orthodontics and Dentofacial Orthopedics 106: 52-59.

30. Eung-Kwon Pae, Andrew Kuhlberg, Ravindra Nanda. 1997. Role of pharyngeal length in patients with a lack overbite. American Journal of Orthodontics and Dentofacial Orthopedics 112: 179-186.

31. F.A. Sosa, T.M. Graber, T.P. Muller. 1982. Post pharyngeal lymphoid tissue in Angle Class I and Class II malocclusions. American Journal of Orthodontics and Dentofacial Orthopedics :299-309.

32. Flowers W. H. 1885. Introduction to the osteology of Mammalia, third edition, MacMillan and Company, London: 158-160.

33. Grant L. E. 1959. A Radiographic study of the hyoid bone position in Angle's Class I, Class II, and Class III malocclusion, Unpublished master's thesis, University of Kansas city.

34. Greenfield Bruce, Steve Kraus. 1989. The influence of cephalostatic ear rods on the position of the head and neck during postural recordings. American Journal of Orthodontics and Dentofacial Orthopedics 95: 312-318

35. Hans Pancherz, Anders Winnberg, and Per-Lennart Westesson.1986. Masticatory muscle activity and hyoid bone behavior during cyclic jaw movements in man. A synchronized electromyographic and videofluorographic study. American Journal of Orthodontics and Dentofacial Orthopedics : 122-131

36. Ioannis P Adamidis and Meropi spyopoulos. 1992. Hyoid bone position and orientation in Class I and Class III malocclusions. 101: 308-312.

37. Ismail Ceylan, and Husamettin Oktay. 1995. A study on the pharyngeal size in different skeletal patterns. American Journal of Orthodontics and Dentofacial Orthopedics : 69-75.

38. J.W. Pim Valk, Aad J. J. Zonnenberg, Cees J. van Maanen and Onno G. Th. Van Wonderen. 1992. The biomechanical effects of a sagittal split ramus osteotomy on the relationship of the mandible, the hyoid bone, and cervical spine. American Journal of Orthodontics and Dentofacial Orthopedics 102: 99-108

39. James F. Bosma. 1963. Maturation of function of the oral and pharyngeal region. American Journal of Orthodontics and Dentofacial Orthopedics 49: 94-104

40. Katsuhiko Saitoh. 2004. Long term changes in pharyngeal airway morphlogy after mandibular setback surgery. American Journal of Orthodontics and Dentofacial Orthopedics 125: 556-561.

41. Kingsley, J. S. 1912. Comparitive anatomy of vertebrates. P. Blakiston's son and Company, Philadephia, pp 63, 73, 101-220.

42. King K. W. 1952. A roentgenographic study of pharyngeal growth. Angle orthodontist 22: 23-37.

43. Lee W Graber. 1978. Hyoid changes following Orthopedic treatment of Mandibular

Prognathism. American Journal of Orthodontics and Dentofacial Orthopedics 48: 33-38.

44. Linder Aronson.S, Leighton BC. 1983. A Longitudinal study of the development of the posterior nasopharyngeal wall between 3 and 16 years of age. European Journal of Orthodontics 5: 47-58.

45. Loannis P. Adamidis and Meropi N. Spyropoulos. 1992. Hyoid bone position and orientation in Class I and Class II malocclusions. American Journal of Orthodontics and Dentofacial Orthopedics : 1-10.

46. Long J. M. 1963. A Cinefluorographic study of Anterior tongue thrust , Unpublished master's thesis, St. Louis University.

47. Lowe AA, Takada , Yoshiaki yamagata. 1985. Dentoskeletal and tongue soft tissue correlate. A cephalometric analysis of Rest position. American Journal of Orthodontics and Dentofacial Orthopedics 88: 333-341.

48. Luc P. M .Tourne. 1995. Growth of the pharynx and its physiologic implications. American Journal of Orthodontics and Dentofacial Orthopedics 99: 29-39.

49. Maggie-Lee Huckabee, Susan Butler, Murray Barclay, Sarah Jit. 2002. The relationship between suprahyoid muscle activity and pharyngeal pressure in normal young adults. Journal of orthodontics :311-312.

50. Mainland D. 1945. Anatomy as a basis for medical and dental practice. P. B. Hoeber, Inc., New York, London. p 580.

51. Michael L. Stepovich. 1965. A cephalometric positional study of the hyoid bone.

American Journal of Orthodontics and Dentofacial Orthopedics 51: 882-900.

52. Michael E. Vermette, Vincent G. Kokich, and David B. Kennedy. 1995. Uncovering labially impacted teeth: apically positioned flap and closed-eruption techniques. The Angle Orthodontist 65: 23-34

53. Miriam Nagae, Fausto Berzin.2004. Electromography: applied in the phonoaudiology clinic. Brazil Journal of Oral Sciences 3: 506-509.

54. Neal H. V. and Rand H. W. 1936. Comparative Anatomy, P. Blackiston's Son and Company: 228-236.

55. Negus. V. E. 1930.The mechanism of larynx. C. V. Mosby Company, St. Louis pp 1-25, 180-188.

56. N.R. Turnbull, J.M. Battagel. 2000. The Effects of Orthognathic Surgery on Pharyngeal Airway Dimensions and Quality of Sleep. Journal of Orthodontics 27: 235-247.

57. Nonglak Pracharktam, Suchitra Nelson, Mark G. Hans, B. Holly Broad bent, Susan Redline. 1996. Cephalometric assessment in obstructive sleep apnea. American Journal of Orthodontics and Dentofacial Orthopedics 109: 410-419.

58. Olwyn Diamond. 1980. Tonsils and adenoids: Why the dilemma? American Journal of Orthodontics and Dentofacial Orthopedics : 495-503.

59. Opdebeeck H Bell WH, Eisenfeld J, Meshelevich D. 1978. Comparative study between

the SFS and LFS rotation as a possible morphogenic mechanism. American Journal of Orthodontics and Dentofacial Orthopedics 74: 509-521

60. Parson. F. G. 1909. Topography and morphology of the human hyoid, Journal of Anatomy and Physiology 43: 279 -290.

61. Pushkar Mehra, Marcos C. Pita, Michael Downie, and Larry M. Wolford. 2001. Pharyngeal airway space changes after counterclockwise rotation of the maxillomandibualr complex. American Journal of Orthodontics and Dentofacial Orthopedics 120: 154-159.

62. Randy J. Hayes, David M. Sarver, and Alex Jacobson. 1994. The quantification of soft tissue cervicomental changes after mandibular advancement surgery. American Journal of Orthodontics and Dentofacial Orthopedics 105: 383-391.

63. Richard H. Barrett. 1961. One approach to deviate swallowing. American Journal of Orthodontics and Dentofacial Orthopedics 47: 726-736.

64. Robert M. Rubin. 1980. Mode of respiration and facial growth. American Journal of Orthodontics and Dentofacial Orthopedics: 504-510.

65. Ruel W. Bench. 1963. Growth of the cervical vertebrae as related to tongue, face, and denture behaviour. American Journal of Orthodontics and Dentofacial Orthopedics 49: 183-214.

66. Samuel L. Lake, R. William Mc Neill, Robert M. Little, and Roger A West. 1981. Surgical mandibular advancement: A Cephalometric analysis of treatment response. American Journal of Orthodontics and Dentofacial Orthopedics: 376-394.

67. S. Takahashi and T. Ono, Y. Ishiwata, T. Kuorda. 2002. Breathing modes, body positions and suprahyoid muscle activity. Journal of Orthodontics 29: 307-313.

68. Schendel S. A. and B. N. Epker. 1980. Results after mandibular advancement surgery: an analysis of 87 cases . Journal of Oral surgery 38: 265-282.

69. Shigetoshi Hiyama, Takashi, Yasuo Ishiwata and Takayuki Kuroda. 2001. Changes in mandibular position and upper airway dimension by wearing cervical headgear during sleep. American Journal of Orthodontics and Dentofacial Orthopedics 120: 160-168.

70. Sicher H. 1960. Oral Anatomy, the C. V. Mosby company, Chapter 4 p65.

71. Smith . J. L. 1956. A Cephalometric radiographic study of the position of the hyoid bone in relation to the mandible in certain functional position , Unpublished master's thesis, North western University.

72. Sprague. J.M. 1943. The hyoid region of placental mammals with especial reference to the bats. American Journal of Anatomy, 72: 385-400.

73. Thompson. J. R. 1941. A Cephalometric study of the movements of the mandible. Journal of American Dental Association 28: 750-761.

74. Timms DJ , Trenouth M.J. 1988. A quantified comparison of craniofacial form with nasal respiratory function ; American Journal of Orthodontics and Dentofacial Orthopedics; 94; 216-21.

75. Walter J. Straub. 1961. Malfunction of the tongue Part II. The abnormal swallowing habit: its causes, effects, and results in relation to orthodontic treatment and speech therapy. American Journal of Orthodontics and Dentofacial Orthopedics 47: 596-617.

76. Wenzel and Williams 1989.craniofacial morphology head posture and airway in mandibular prognathism. American Journal of Orthodontics and Dentofacial Orthopedics :138-143